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Open Space Visitors' Attitudes toward Ebikes on Natural Surface Trails

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Executive Summary

This article examined visitors' attitudes toward electric motorized bikes (ebikes) on natural surface trails and the reasons for support or opposition to ebikes. On-site survey data (n = 536) were obtained from visitors to Devil's Backbone Open Space (DBOS) in Larimer County, Colorado in 2020. Findings suggested that visitors' ebike attitudes differed by demographics (i.e., age, gender, residence), and trip characteristics (i.e., survey location, visits per year, primary activity). We also observed a positive correlation between perceived ebike familiarity and support. A content analysis of responses to an open-ended question revealed that concerns over safety, crowding, and beliefs that ebikes do not belong in natural environment were major reasons for opposing ebikes. The potential to expand trail access to people with mobility difficulties was the main reason for a supportive attitude. Visitors' attitudes were also associated with misperceptions about ebikes (e.g., ebikes are noisy), suggesting the need for effective public communication. We suggested several practical recommendations for managing ebikes in natural areas. First, correct information regarding ebikes (e.g., ebikes are generally quiet) needs to be disseminated. Ebike demonstration sites at popular trailheads would allow visitors to personally experience ebikes and better understand the technology. Information boards could describe ebikes' mechanisms and environmental impact to clarify some misperceptions. Second, concerns with safety and speed could be addressed by developing comprehensive bike regulations (e.g., speed limits, trail etiquette education) for all bikers. Setting up speed limit signs and monitoring devices on trails might minimize some visitor concerns. Third, exceptions could be made for users with mobility disabilities; these exceptions should be advertised widely so all visitors were aware of and understand the exceptions.

Keywords

Electric motorized bikes (ebikes), open space visitors, ebike attitudes, ebike familiarity, natural surface trails, misperceptions of ebikes, management recommendations

Introduction

Electric motorized bikes (ebikes) have gained popularity in both urban and outdoor environments (Mitterwallner et al., 2021; Nielsen et al., 2019). With an integrated electric motor, riders can choose to turn on pedal or throttle assistance (or both) and exert less physical effort than conventional bikes. Ebikes serve both utilitarian (e.g., hauling goods, commuting), and leisure purposes (e.g., exercising, enjoying outdoors). Previous research has suggested that ebike users ride more frequently and cover longer distances (Fyhri & Fearnley, 2015; MacArthur et al., 2014). With the added ease and health benefits (Plazier et al., 2017), ebikes have increased access for people with mobility challenges (Leger et al., 2019). There are, however, public concerns regarding ebikes on trails such as safety, speed, crowding, and user conflicts (Nielsen et al., 2019).

Whether ebikes are allowed on trails (paved and/or natural surface trails) varies by jurisdiction. Natural surface trails refer to dirt trails with ongoing management (Nielsen et al., 2019). Some land management agencies only allow ebikes on paved trails (e.g., Larimer County Department of Natural Resources (LCDNR), City of Fort Collins), while other agencies (e.g., Jefferson County Open Space) also allow some ebikes on natural surface trails (Nielsen et al., 2019). Empirical studies on open space users' attitudes toward ebikes, however, are limited. To better inform decision-making regarding ebikes on natural surface trails, we surveyed visitors at Devil's Backbone Open Space (DBOS) in Colorado in 2020 and examined their attitudes toward ebikes, as well as the reasons for their support or opposition to ebikes. Specifically, we sought to answer two research questions. First, what are the relationships between open space visitors' characteristics and their attitudes towards ebikes on natural surface trails? Second, what are the reasons for visitors' attitudes? Based on the findings, we proposed several practical implications and recommendations for public land managers to consider.

Literature Review

The Growing Popularity of Ebikes

Ebikes provide power assistance to riders through an integrated electric motor and help users maintain or achieve speed with less effort (Fishman & Cherry, 2016). Users can also choose to not use the assistance and ride the ebike as a conventional bike. Studies have shown that ebike use can provide riders with health benefits similar to conventional bike use, with additional benefits of ease and convenience (Hoj et al., 2018). There are three main categories of ebikes in Colorado (Nielsen et al., 2019). Class 1 ebikes only provide pedal assistance when the rider is pedaling and cease assistance at 20 miles per hour. Class 2 ebikes provide throttle assistance that can propel the bike without pedaling and also cease assistance at 20 miles per hour. Class 3 ebikes are like Class 1 with pedal assistance only, except assistance ceases at 28 miles per hour. This article focused on Class 1 ebikes on natural surface trails.

Ebikes have gained popularity worldwide in recent decades. China and the United Kingdom (UK), for example, have seen exponential growth of ebikes (Fishman & Cherry, 2016; Melia & Bartle, 2021). In March 2021, a news article (Ricker, 2021) indicated that more than 50% of all new bikes sold in Germany and the Netherlands were from ebike sales. The United States has also experienced soaring sales of ebikes. As of April 2021, there was a 139% increase in ebike sales (681 million dollars) in the

U.S. compared to the same time in 2020, with no signs of slowing down (Ricker, 2021). Along with this trend, ebike use on recreational trails is also on the rise. For example, in Germany from 2015 to 2019, conventional mountain bike sales decreased by half, while electric mountain bike sales grew eightfold, suggesting a significant shift in riders' bike choices in mountain recreation (Mitterwallner et al., 2021). Many cities in the U.S. (e.g., Seattle, Boise, Boulder) have pilot programs that allow ebikes on certain trails (Rails-to-Trails Conservancy, n.d.). As shown in an ebike share program in Park City, Utah (He et al., 2019), proximity to recreational centers and bike trails positively affected ebike share and usage, supporting the trend of ebike use on recreational trails. It is both timely and highly relevant to examine public's attitudes toward ebikes on recreational trails.

Public's Attitudes toward Ebikes

Although previous studies examined attitudes toward ebikes from both user and public perspectives, these studies were often conducted in a transportation context. For example, in Canada, Edge et al. (2020) regarded ebikes as an alternative sustainable transportation method that shifted people away from cars. Ebike users in the UK were often converted from conventional bike users due to their ease and convenience (Melia & Bartle, 2021). In North America, MacArthur et al. (2014) suggested that ebikes help users to bike more often, travel longer distances, carry more cargo, and expand access. Studies have shown that the increasing adoption of ebikes is influenced by the growing awareness and familiarity of ebikes (Handy & Fitch, 2020; Simsekoglu & Klöcknera, 2019), which is further fueled by increasing ebike sharing platforms such as Citi Bike.

In a recreation context, there is a lack of research examining ebike attitudes (Fishman & Cherry, 2016), especially from other open space users' perspective. Haustein and Møller (2016) found that recreational ebike users had a very positive attitude toward ebikes, especially for longer trips. Other stakeholders, however, may hold varying beliefs and tolerances for ebikes in open space areas. Hikers, runners, dog-walkers, wildlife viewers, and horseback riders may all use the same trails. Because recreational trails can be narrow (especially for natural surface trails), ebikes on trails may heighten concerns regarding safety and crowding. Although ebikes are easy to use and convenient, some users may see ebikes as less sporting. For example, Chaney and colleagues (2019) analyzed mountain bikers' sentiment toward e-mountain bikes and suggested a non-welcoming attitude. Mountain bikers held a "rite of passage" belief and felt that mountain trails had to be earned; ebikes were viewed as "cheating." However, because of the "newness" of ebike riding in this context, ebikes are often managed differently under specific jurisdictions. It is necessary to examine how visitors to public land perceive ebike use on natural surface trails for developing effective public communication and use regulations.

Existing studies of ebike purchase intentions and adoption provided valuable insights regarding factors that may affect other open space users' attitudes. Research has consistently suggested that "familiarity" is a predictor of ebike attitudes (e.g., Simsekoglu, & Klöckner, 2019). Research on new technology adoption (e.g., electric vehicles), has indicated that knowledge or familiarity with the new technology plays a critical role resulting in adoption or barriers to adopt (Egbue & Long, 2012). A higher level of familiarity and experience with ebikes increases support for and adoption of ebikes (Simsekoglu, & Klöckner, 2019). Simsekoglu and Klöckner (2019) suggested that compared to ebike users, non-users are less likely to perceive benefits of ebikes and more likely to perceive barriers such as usability and safety. This difference can be attributed

to individuals' familiarity of ebikes as increased use of ebikes contributes to higher perceived benefits, similar to electric vehicle adoption (Egbue & Long, 2012; Krause et al., 2013). Other factors such as social and cultural norms and individual characteristics (e.g., age, mobility) are also known to influence ebike adoptions (Haustein & Møller, 2016; Simsekoglu, & Klöckner, 2019). For example, individuals 50 to 55 were most frequent users of an ebike share program, followed by those in the 25 to 30 age group (He et al., 2019).

Other open space users' attitudes are likely to be influenced by their familiarity with ebikes as well. Drawing on existing literature, we examined how DBOS visitors' demographic characteristics (i.e., gender, age, residence), trip characteristics (i.e., survey location, visits per year, primary activity), and perceived familiarity with ebikes affected attitudes toward ebikes on natural surface trails. We also conducted a content analysis of respondents' written responses regarding the reasons for support or opposition to ebikes.

Methods

Study Area

Devil's Backbone Open Space in Loveland, Colorado, is managed by Larimer County's Department of Natural Resources (LCDNR). DBOS offers 17.25 miles of well-maintained natural surface trails that connect to both Horsetooth Mountain Open Space and the City of Fort Collins Coyote Ridge Natural Area. This 3,000-acre open space offers towering rock formations and long vistas of native shrublands and grasslands. There are two major access points into DBOS. The North Trailhead (i.e., Blue Sky Trailhead) is west of Fort Collins, Colorado; the South trailhead is in just west of Loveland, Colorado. The North Trailhead is popular among bikers and runners. The South Trailhead (i.e., Main Trailhead) is popular for sight-seeing, short hikes, and walking dogs. In recent years, LCDNR has witnessed increased visitation, especially at locations near urban areas which include DBOS.

Survey Administration

On-site surveys were conducted by trained interviewers at both the South and North Trailheads from September 1 to October 13, 2020. Survey administration was suspended on October 14 due to the proximity of the Cameron Peak Fire and closure of the open space. Sampling was based on a stratified-cluster random sampling design to capture different groups of visitors during this period (See Vaske, 2019, for a detailed explanation). Sampling proportions for the two locations were stratified by weekdays and weekends. Within each stratum, all respondents exiting the trailhead were interviewed (i.e., the cluster).

Surveys were administered during two-hour shifts in the mornings, afternoons, and evenings. Sampling times (shifts) were randomly selected. Survey administration in the mornings always began at 9 a.m. Given the average visitation times of about 1-2 hours at DBOS, the sampling procedures captured earlier visitors exiting the property. Overall, the survey administration shifts were consistent with the general patterns of visitors at DBOS and provided a representative sample of the population. A total of 536 visitors completed the survey with a response rate of 80%. Of these, 416 surveys (78%) were collected at the South Trailhead (due to higher visitation) and 120 (22%) at the North Trailhead. Slightly less than two-thirds of all surveys were obtained on weekends.

Variables Measured

Attitudes toward ebikes were measured by asking respondents to rate their level of support or opposition to allowing Class 1 electric motorized bicycles on natural surface trails. Options were based on an 8-point scale, where 1 through 3 denoted strongly opposed to slightly opposed, 4 was neutral (i.e., neither support nor oppose), 5 through 7 was slighted support to strongly support, and 8 was not sure. Similar with the one-item measure of familiarity with ebikes in Simsekoglu and Klöckner (2019), perceived familiarity toward ebikes was measured by asking "Overall, how familiar are you with electric motorized bicycles?" on a 6-point scale where 1 denoted not familiar and 6 was extremely familiar. The survey also included an open-ended question asking respondents to briefly explain reasons behind their reported attitudes. These written responses were subjected to content analyses to reveal users' perceptions and concerns of ebikes on natural surface trails. Demographic variables included gender, age, and residence. Trip characteristic variables included survey location, visits per year, and primary activity. Table 1 shows the response categories for the demographic and trip characteristic variables.

Analysis Methods

Quantitative data such as respondents' demographic information and attitudes were analyzed through descriptive analyses, including frequency, mean differences, and correlations. Chi-Square Goodness of Fit with Cramer's V as the effect size were used to compare groups based on age, gender, and user types. Relationships between age and ebike attitude, as well as perceived ebike familiarity and ebike attitude were analyzed through Pearson's r. These tests were conducted through SPSS 26.

Qualitative data of respondents' perceptions of ebikes on natural trails were analyzed through a content analysis. Specifically, after respondents reported their attitudes toward ebikes on natural surface trails, they briefly explained their thinking behind the evaluation. Out of the 536 responses, 259 individuals provided written text-based answers. Following Hsieh and Shannon (2005), a content analysis of these answers was conducted. A draft of general themes in the responses were defined and a code sheet detailing all original responses with corresponding codes was developed by one researcher. Since the 259 responses tended to be short and succinct, a team of four researchers was able to review all responses and corresponding codes independently. After two rounds of discussions and revisions, full agreement was reached. Thirteen themes representing respondents' reasons behind their attitudes toward ebikes on natural surface trails were developed. A detailed explanation of each code as well as example original responses is provided in Table 2. The frequency of each code was then associated with different attitudes (oppose, neutral/not sure, support) to reveal underlying reasons behind the attitude.

In this process, a few rules were applied. The analysis is focused on the frequency of codes overall, as opposed to frequency of individuals who mentioned a certain code. When responses mentioned more than one reason (e.g., "Speed and trail wear"), multiple codes (speed and environment) were assigned to capture the content in this response. When the theme of a response was less obvious, the code was decided based on both the associated attitude (e.g., support or oppose) from the previous question and the text-based response. For example, the original response "Adds another user" was coded under crowding (i.e., ebikes can increase trail use and raise crowding issues) instead of access (i.e., ebikes can help people with mobility disabilities to access trails). This occurred because the respondent suggested a "strongly oppose" attitude. Respons-

es that were less relevant or informative to the question (e.g., "ATV have ruined my favorite sport") were coded as other. Some themes were split into multiple subcategories to reveal more detailed information of the response in data analysis. For example, there were three situations under the code "indifferent": a) I don't care, b) ebikes are no different from other bikes, c) I am not from here so I don't care. By analyzing the codes in a hierarchical structure (Table 2), the results highlighted the reasons and concerns behind respondents' attitudes toward ebikes on natural surface trails.

Results

Attitudes toward Ebikes

Nearly half (48%) of all respondents were opposed to ebikes on natural surface trails (Table 1). About a quarter (23%) supported ebikes, and 29% were not sure. Males were more supportive of ebikes (67%), while females were more neutral or unsure (57%) ($\chi^2 = 16.11$, $p < .001$, Cramer's $V = .17$). Age was negatively correlated with ebike attitude ($r = -.104$, $p < .05$). Older respondents were the less supportive of ebikes than younger visitors. In 25-34 age group, 28% of respondents supported ebikes, while 45% were opposed to ebikes. In the 35-44 age group, 22% supported ebikes, while 53% opposed. In each age group, there were consistently more respondents opposed. Ebike attitudes also differed between hikers and bikers. Mountain bikers (31%) were more likely to support ebikes compared to hikers (16%, $\chi^2 = 13.65$, $p < .01$, Cramer's $V = .18$). Consistent with previous literature on ebike adoption, perceived ebike familiarity was also positively correlated with support for ebikes on natural surface trails ($r = .32$, $p < .01$). Visitors who were more familiar with ebikes were more likely to support the use of ebikes on natural surface trails.

Reasons behind Visitors' Attitudes toward Ebikes

In addition to the revealed attitudes (oppose, neutral/not sure, support), corresponding written responses that explain such attitudes were coded. We identified the frequency of attitudes (oppose, neutral/not sure, support) associated with each code. Overall, safety concerns were the most prominent reason behind visitors' attitudes toward ebikes on natural trails. This theme was mentioned 53 times, and 79% were related to an oppose attitude. Such concerns were associated with speed (too fast), worrying about reckless riders, danger to other users, and pets on natural surface trails. The second most frequently used theme was "access" (mentioned 41 times). This theme suggested that respondents believed that ebike use can expand trail access to people, especially those with mobility constrains (e.g., seniors, children, people with disabilities). About two-thirds (63%) of the mentions were tied to a support attitude. However, 27% of the mentions were linked to an oppose attitude with the caveat that ebikes should only be allowed for people with mobility disabilities.

Crowding was the third most frequently mentioned theme (39 times). About three-quarters (74%) of the mentions were tied to an oppose attitude (7% were associated with a support attitude, 18% with an indifferent attitude). This theme often coexisted with the "access" theme, suggesting that respondents were sometimes conflicted. On one hand, they recognized the importance of expanding access to people with mobility difficulties. On the other hand, they worried about a spike in trail traffic, which could increase danger to themselves and other users.

Respondents also suggested ebikes don't belong on natural surface trails because they have motors. Following this concern, damage to the environment and the risk of

Table 1
Demographics and Trip Characteristics by Attitude toward Ebikes (n = 536)

	Attitude toward Ebikes [1]					
	Support *n* = 122 23%	Not Sure *n* = 157 29%	Oppose *n* = 257 48%	χ^2	*p*-value	Cramer's *V*
Demographics						
				16.27	<.001	.17
Gender						
Male	28	23	49			
Female	17	37	47			
				19.32	<.05	.20
Age						
16 to 24	19	50	31			
25 to 34	28	27	45			
35 to 44	22	25	53			
45 to 54	23	31	46			
55 to 64	22	24	58			
65 +	19	23	58			
				19.60	<.001	.19
Resident of Larimer County						
Yes	25	23	52			
No	19	41	41			
Trip characteristics						
				26.05	<.001	.21
Survey location						
South trailhead	20	34	46			
North trailhead	33	13	54			
				22.46	<.05	.20
Visits per year						
1 visit	17	38	46			
2 to 4 visits	24	31	46			
5 to 9 visits	28	21	51			
10 to 14 visits	25	21	55			
15 to 24 visits	39	16	45			
25+ visits	25	8	67			
				13.65	<.01	.18
Primary Activity						
Hiking	16	34	50			
Mountain Biking	31	24	45			

[1]*Note*: Cell entries are percentages.

This question was phrased: Currently motorized vehicles (except by permit for this study) are not allowed on Larimer County natural surface trails. Please rate your level of opposition or support toward expanding natural (soft) surface trail uses to include Class 1 electric motorized bicycles.

increased speeds were mentioned the most. All three themes were mentioned 28 times. However, these themes may play a significant role in on affecting respondents' attitude (e.g., such reasons were often associated with an oppose attitude toward ebikes). For example, 93% of the mentions of "ebikes do not belong in a natural setting" were tied to an oppose attitude. Concerns about the natural environment were related to "ebikes do not belong in a natural environment" sentiment. Respondents worried that motorized ebikes can be destructive to the natural surface trails and the natural area. Sixty-one percent of the mentions were associated with an oppose attitude, while 29% were associated with a support attitude. The reasons behind a support attitude with environmental concerns can be attributed to the perception that ebikes can expand access to more users, and ebikes are no more damaging than regular mountain bikes. Last, the theme of "speed" was also a major reason behind respondents' ebike attitudes. All mentions

Table 2
Code Description and Frequency

Codes	Themes	Example response	Frequency
Safety	Safety concerns, such as danger of ebikes posed to riders and others on the trail.	"I don't want to get mowed down by a bike"	53
Access	Ebikes can help people with mobility disabilities to access trails.	"Access to elderly or handicapped would be great"	41
Crowding	Ebikes can increase trail use and raise crowding issues; ebikes should have separate trails.	"Expect it would make it too crowded"	39
Environment	Ebikes bring damage to natural trails and environment, disturb wildlife.	"Natural area shouldn't get ruined"	28
Not Natural	Ebikes are motorized and thus not a fit for natural surface trails.	"Motorized or energized vehicles don't belong on trails"	28
Speed	The speed of ebikes can be a concern.	"Too fast, against the spirit of trails"	28
Indifferent	An indifferent attitude; ebikes are no different from regular bikes.	"Don't really care one way or the other"	22
Noise	Respondents perceive Ebikes as noisy or quiet.	"Noise pollution"; "Since they are quiet I am okay with sharing the trail."	20
Others	Reasons that are less relevant to the question or deemed personal.	"ATV have ruined my favorite sport"; "I personally own an ebike"	16
Earned sport	Trails are earned and riding ebikes is cheating; pedal power only.	"You should put the work in for the enjoyment."	14
Lack of knowledge	Lack of knowledge of ebikes.	"I don't know enough about them"	14
Courteous	Ebikers should be educated of trail rules and courteous to other users on trails.	"I think as long as courteous, no issue"	8
Fun	Ebikes are considered fun to ride.	"It's just a bike that makes up hill more fun"	5

of speed suggested ebikes can be too fast. Nearly 90% of the mentions were associated with an oppose attitude (7%, or two mentions were for support attitude). Although Class 1 ebikes cease to provide petal assistance at 20 miles per hour, respondents believed motorized ebikes can be too fast on trails, which may damage natural surface trails and serve as a danger to others.

Several other themes emerged including ebike noises, ebikes are cheating, lack of knowledge of ebikes, as well as concerns of ebike riders' courtesy and knowledge of trail rules are also worth considering. For example, 85% of the "noise pollution" responses (17 times out of 20) suggested ebikes are noisy, and 88% of these mentions were associated with an oppose attitude. This suggested the need for effective communication of how loud ebikes can be on trails. Riding ebikes was also perceived as cheating; all mentions were tied to an oppose attitude. Lack of knowledge of ebikes was the main contributor to respondents' "indifferent/don't know" attitude, which suggested

more public communication and education is needed to inform respondents on ebike features and uses. Ebike riders' courtesy to others also informed attitudes. Visitors were more likely to support ebike use on natural surface trails if riders were versed in trail etiquette and act courteous and careful on natural surface trails.

After weighing responses by multiplying the times of the code mentioned and the percentage associated with an oppose or support attitude, results indicated that the reasons behind an oppose attitude toward ebikes can be ranked as safety concerns, increased crowding, ebikes do not belong in a natural setting, too fast, and damage to environment. As for the support attitude, expanding access to people with mobility difficulties was the most important reason.

Discussion

This article revealed several insights regarding open space visitors' attitude toward Class 1 ebikes on natural surface trails. Almost half of the respondents (48%) held an opposed attitude, while only 23% of respondents supported ebikes on natural surface trails. There was an overall negative relationship between support attitude and age. In each age group, however, there were respondents holding support or oppose attitudes.

Male respondents were more supportive of ebikes, while female respondents were more likely to be neutral or unsure. This might be because over three-quarters of mountain bikers were male (82%), while 60% of hikers were female. Mountain bikers were more supportive of ebikes of natural surface trails than hikers. This study also identified a positive correlation between perceived ebike familiarity and support. Ancillary analyses indicated that mountain bikers were more familiar with ebikes than hikers. Mountain bikers' familiarity with bikes in general, may have contributed to their support. This speculation is consistent with previous findings that familiarity can promote adoption of ebikes (Simsekoglu & Klöcknera, 2019). This positive correlation between familiarity and support attitudes is critical as ebikes gain public awareness and popularity; support of ebikes on natural surface trails may also grow. Individuals' support for ebikes, however, can also originate from other reasons such as interest in new technology (e.g., electric car adoption) and pro-environment attitudes (Edge et al., 2020). It is plausible that people who support ebikes were more likely to pay attention to ebike information and have higher ebike familiarity.

Based on the content analysis of visitors' reasons behind their attitude toward ebikes on natural surface trails, respondents' opposition attitude was mostly attributed to safety concerns, crowding, ebikes being motorized, speed, and environmental concerns. The support attitude was mostly attributed to expanding access to people with mobility challenges. These findings are consistent with a recent literature review (Nielsen et al., 2019). Concerns such as safety, crowding, and speed were common for bicycles on trails as well. As ebike use for recreation is relatively new, there is a lack of familiarity, and visitors are likely to have concerns regarding ebikes on trails. The content analysis revealed the reasons behind an oppose attitude were based on respondents' assumptions. For example, respondents opposed ebikes on natural surface trails because ebikes are motorized and perceived as inappropriate in natural environments. The Department of the Interior (DOI), however, exempted ebikes from the motorized vehicle category in August 2019 on DOI lands (it is still up to the state and local jurisdictions to determine if ebikes are considered motorized vehicle).

Respondents also suggested ebikes are noisy or too fast. It is likely that these perceptions were based on the negative connotations of motors in terms of noise and high speed. Ebikes are equipped with electric motors and designed with speed limitations. Compared to conventional bikes, ebikes can generate additional light noise (low sound volume) from the electric motor when assistance is engaged. However, there is a lack of studies examining the decibel level of ebike motors. In electric vehicle research, studies noted that an electric motor emits a low level of sound which is often difficult to detect for pedestrians (Lee et al., 2017). As a result, countries (e.g., Japan, U.S.) are now requesting warning sound systems (e.g., a warning sound generator) to be installed in electric cars, so that pedestrians are more likely to be aware of electric cars approaching (Lee et al., 2017). Similarly, ebikes with electric motors engaged are unlikely to produce significant noises. The perception and impact of sound are also affected by proximity to the sound source and duration of exposure (World Health Organization, 2015). Other trail users are unlikely to perceive noise annoyance from ebikes that are passing by. In terms of ebike speed, Class 1 and 2 ebikes cease assistance at 20 miles per hour. However, this speed can be perceived as fast especially in uphill sections. Implementing speed limits for all bikes might be necessary.

Respondents with an oppose attitude also cited concerns of ebikes damaging the natural environment. Previous research has shown that ebikes were similar to conventional mountain bikes in terms of impacting soil displacement, and both were significantly less impactful than gas-powered dirt bikes (International Mountain Biking Association, 2015). Similar to Chaney et al. (2019) who studied the mountain biking community, some respondents in our study believed riding ebikes is "cheating." These respondents perceived ebikes do not require pedaling (i.e., self-effort). Class 1 ebikes, however, do require pedaling to activate assistance for riders. Clarifying these misperceptions may effectively inform public's attitude toward ebikes on natural surface trails. Finally, expanding access to people with mobility challenges was identified as the primary reason behind respondents' support attitude toward ebikes, which should be a strong consideration for land management agencies when deciding whether allowing ebikes on trails.

Management implications and Conclusions

In summary, this study revealed open space visitors' attitudes at Devil's Backbone Open Space in Larimer County toward Class 1 ebikes on natural surface trails and the reasons behind the attitude. We propose several practical implications for land managers to consider should they decide to expand or limit ebike use on natural surface trails. The following recommendations focus on Class 1 ebikes only.

First, findings revealed several common misperceptions of ebikes (e.g., speed and damage to environment). Thus, accurate information regarding ebikes (e.g., ebikes are generally quiet) is encouraged to be disseminated through public communication (such as from ebike manufactures, marketers and open space decision-makers). For example, ebike demonstration sites at popular trailheads could allow visitors to personally experience ebikes and better understand the technology. The demonstration can show the light sound ebikes generate when engaged. Class I ebikes only provide assistance when users are pedaling. This demonstration could also facilitate public perception of ebike riding as an alternative sport or exercise method (as opposed to "cheating"). The demonstration could also highlight the benefits of ebikes for individuals with mobility

difficulties. Second, many of the respondents' concerns were related to speed, crowding, and trail etiquette. A lack of familiarity with ebikes may have heightened these concerns (Nielsen et al., 2019). Land managers are encouraged to develop comprehensive bike regulations for all bikes. For example, some land management agencies have implemented a 15 miles per hour bike speed limit on trails (e.g., Denver Parks and Recreation Department), but many riders are often not aware of this speed limit, and reinforcement of this regulation can be difficult. Passing by other visitors at this speed (especially when unannounced) can be perceived as fast and dangerous. Riders should be informed of the speed limit for all bikes and provide necessary education regarding trail etiquette. Setting up visible speed limit signs and monitoring devices on trails may can help regulate biker speed. It is also recommended to provide signs that explain common trail etiquette for bikers, especially for ebike riders (e.g., obey the speed limit, slow down when there are other users present, and make audible signals before passing) at trailheads. Land managers should also consider more effective capacity management strategies. The increasing popularity of ebikes may encourage more trail riders and may lead to riders venturing into more remote areas. Studies regarding trail use patterns may identify the peak hours for different trail uses and suggest designated times or locations for different users. Mandating (or suggesting) one-way trails and designating biker only trails can also help ease traffic congestion.

Third, exceptions could be made for users with mobility disabilities; these exceptions should be advertised widely so all visitors are aware of the exceptions. For example, Larimer County Department of Natural Resources now allows ebikes on paved and natural surface trails that allow regular bikes for individuals with a mobility disability (Larimer County, 2021). Speed limits and rider etiquette should be widely communicated to the public.

There were several limitations to this study. First, the investigation was conducted in early fall of 2020. The COVID-19 pandemic may have affected the responses. For instance, there might be new visitors who were encouraged to visit DBOS as a new recreation option to decrease virus transmission risk. We may also have missed some previously frequent visitors who were discouraged to visit DBOS to avoid contact with others. Second, we only collected data from one site in Larimer County. Future data should be collected from other sites that may experience ebikes (whether or not they are allowed). Third, perceived familiarity of ebikes was measured with one question, which can be improved with a multiple-item measurement scale in future studies. Future studies can also build off this research by identifying relevant theories and constructs explain how people form their attitude toward ebikes. For example, the technology acceptance model (TAM) (Davis et al., 1989) may offer strong theoretical support that explains why users adopt ebikes based on perceived usefulness and ease-of-use.

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